FORCE MAIN CONDITION:
WHAT HAVE YOU GOT?

Serve your customers well. Plan ahead.

CSRMA and
Chris Ewers, P.E.
(Ewers Engineering)
Recommended reading

The following articles provide a range of data, including California and national statistical likelihoods of force main failure, California and national sanitary agency use of condition assessment practices, and projections of pressure pipe failure rates and tools for rehabilitation.

They’re also available for free.


“Buried No Longer: Confronting America’s Infrastructure Challenge,” AWWA, February 2012

2012 CSRMA Member Force Main Risk Management Survey Results, January 2013


If you have questions about condition assessment and its application, please contact me:

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Risk

The possibility of failure and consequent damage
Likelihood of failure: 5-year record*

Category 1 spills:

**Number**
- 248 Force Mains
- 5,857

**Volume**
- 16,042,000 gallons
- 119,728,000 gallons

*California State Water Resources Control Board SSO database, 1/5/2013*
Category 1 spills by year

8,700,000 gallons spilled

*California State Water Resources Control Board SSO database, 1/5/2013
Consequence of failure: Example 1

Spill: 24" Force main rupture, 3/31/07-4/3/07
Volume: 7,300,000 gallons into lagoon
Consequence of failure: Example 1

Costs

<table>
<thead>
<tr>
<th>Costs</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$4.4 Million</td>
</tr>
<tr>
<td>State fine</td>
<td>$1.1 Million</td>
</tr>
<tr>
<td>Lagoon</td>
<td>$0.5 Million</td>
</tr>
<tr>
<td>Staff/admin.</td>
<td>$?</td>
</tr>
<tr>
<td>Attorneys</td>
<td>$?</td>
</tr>
<tr>
<td>Partial Total</td>
<td>$5.6 Million</td>
</tr>
<tr>
<td>Est. Pipe Cost</td>
<td>$3.2 Million</td>
</tr>
</tbody>
</table>
Consequence of failure: Example 1

Time


(5 years, 8 months of agency time)
<table>
<thead>
<tr>
<th>Spill</th>
<th>Multiple system failure, flooding at WWTP, 1/2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>7,000,000 gallons into Pacific</td>
</tr>
</tbody>
</table>
Consequence of failure: Example 2

Costs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction, repairs (est.)</strong></td>
<td>$50 Million</td>
</tr>
<tr>
<td><strong>State fine</strong></td>
<td>$2.3 Million</td>
</tr>
<tr>
<td><strong>Staff/admin.</strong></td>
<td>$ ?</td>
</tr>
<tr>
<td><strong>Attorneys</strong></td>
<td>$ ?</td>
</tr>
<tr>
<td><strong>Partial Total</strong></td>
<td>$52.3 Million</td>
</tr>
</tbody>
</table>
Consequence of failure: Example 2

Time

Cleanup-Construction | 1/2008-today

(5 years and counting of agency time)
Goal

Put you on the path to a healthy, well-managed system of force mains.
Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation
Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation
Force Mains in California

- Age
  - Average: 32 years

- Length per agency
  - Average: 15 miles

*CSRMA survey of member agencies on force mains, 12/2012
Condition Assessment in California*

*CSRMA survey of member agencies on force mains, 12/2012
Force Mains in the U.S. *

Age of force mains

- > 50 years: 2%
- 25-50 years: 30%
- 0-25 years: 68%

Condition Assessment in the U.S.*

- Budget: $4.13/foot (average)
- Spent: $24.05/foot (average)

(Includes inspection, assessment, repair, and cleanup.)

What we are doing: Conclusions

- Force mains
  - Small diameter (4”-20”)
  - Ferrous (DIP, CIP, Steel ~60%)
  - <<50 years old when replaced
- We underestimate repair and cleanup costs from failures.
  - Condition assessment is not effectively used.
Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation
Goal of Condition Assessment

- Determine likelihood of failure:
  - Know where and when to repair and maintain
  - Know how long to maintain until replacement
  - Use time until replacement to set aside funding
Goal of Condition Assessment

- **Cost ($)**
- **Time**
- **Funding period**

- Replacement cost
- Maintenance, repair cost

- Replacement
Third-party construction emergency!

Goal of Condition Assessment

Cost ($)

Time

Replacement cost

Maintenance, repair cost

Replacement?
Goal of Condition Assessment

Force main corrosion

![Graph showing cost ($) vs time with categories such as replacement cost, maintenance, repair cost, and funding period, with a shaded area indicating the replacement period.](image)
Indirect condition assessment tools
Inventory

Know what you have to get started.

- Identify and map
  - Pumping facilities
  - Force mains and valves
  - Access points

- Materials, diameters, age of pipe, repair history

- Preparation: Minimal
- Cost: Staff time
Site visit

- Verify mapping, diameter, materials
- Evaluate air release/air vacuum valves
- Signs of leakage, construction disturbance

Know what you have to get started.

- Preparation: Minimal
- Cost: Staff time
Performance tests

Know what you have to get started.

- Lift station: pressure/flow
- Pressure: Transient max.?
- Corrosion test stations
- Preparation: Minimal
- Cost: Staff time, equipment
Visual inspection: CCTV

Know what you have to get started.

- Requires force main out of service for extended duration
- Access may require construction
- Dark pipe reduces value
- Look for seepage into dewatered pipe

- Preparation: Depressurize, dewater, install or use access
- Cost: Staff time, equipment ~ $3/foot
Leak and gas pocket detection

Know what you have to get started.

- Technology: Acoustic sensing
  - In-line
    - Tethered: Sahara hydrophone
    - Free-swimming: SmartBall hydrophone
  - Acoustic field testing
Leak and gas pocket detection

Technology: Acoustic sensing (hydrophone)

- Aided by high pressure, high flow (Re ≥ 1,000)
- Sound of wastewater passing gas pockets permits their detection
Leak and gas pocket detection

Technology: Acoustic sensing (hydrophone)
- Field hydrophones
  - Attach hydrophone to live pipeline
- Sahara
  - Tethered: Refined, repeatable location ($\geq 0.25$ gpm leaks)
- Smartball
  - Free-swimming: Accommodates long intervals at 3 mph min.
# Leak and gas pocket detection

<table>
<thead>
<tr>
<th></th>
<th>In-Line</th>
<th>Field hydrophones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sahara</td>
<td>Acoustic</td>
<td>Acoustic</td>
</tr>
<tr>
<td>SmartBall</td>
<td>Acoustic</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Sizes</td>
<td>≥ 4&quot;</td>
<td>≥ 6&quot;</td>
</tr>
<tr>
<td></td>
<td>≥ 6&quot;</td>
<td></td>
</tr>
<tr>
<td>Preparation</td>
<td>Access: 2&quot; tap</td>
<td>Access: 4&quot; port</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access: Pipe wall or appurt.</td>
</tr>
<tr>
<td>Cost (mobilization/$/mi.)</td>
<td>$35,000/$35,000</td>
<td>$25,000/$12,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment</td>
</tr>
</tbody>
</table>
Direct condition assessment tools
Structural integrity assessment

- Technology: Acoustic sensing
  - Acoustic field testing

Combine acoustic tools to assess pipe wall thickness
Structural integrity assessment

Technology: **Acoustic sensing (hydrophone)**
- Hydrophone receives/correlates pipe noise
- Speed of wave reflects rigidity of pipe
- Bulk modulus of sewage needed for pipe thickness
## Structural integrity assessment

<table>
<thead>
<tr>
<th></th>
<th>In-Line</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
<td></td>
<td>Field hydrophones</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td></td>
<td>Acoustic</td>
</tr>
<tr>
<td><strong>Sizes</strong></td>
<td></td>
<td>All</td>
</tr>
<tr>
<td><strong>Preparation</strong></td>
<td></td>
<td>All</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td></td>
<td>Access: Three 6” pipe wall seats</td>
</tr>
<tr>
<td>(mobilization/$/mi.)</td>
<td></td>
<td>x/$30,000</td>
</tr>
</tbody>
</table>

*Not yet commercially available*
Structural integrity assessment

- **Technology:** Ultrasonic Testing
  - Coating removal, cleaning
  - Calibration with pipe wall required
  - Hand-held: B-Scan
  - Circumferential: Guided-Wave (50-500 ft.)
Structural integrity assessment

- Technology: **Broadband Electromagnetic Testing**
  - Scans through 2” coating
  - Uses eddy current sensing
  - Data interpreted in Australia
  - Slow process finds relative changes in wall
## Structural integrity assessment

<table>
<thead>
<tr>
<th>Technology</th>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic: B-Scan, Guided-Wave</td>
<td>Broadband Electromagnetic</td>
</tr>
<tr>
<td>Material</td>
<td>Ferrous</td>
</tr>
<tr>
<td>Sizes</td>
<td>≥6“</td>
</tr>
<tr>
<td>Preparation</td>
<td>Access: Full diameter, remove coating</td>
</tr>
<tr>
<td>Cost (mobilization/$/mi.)</td>
<td>$3,500/read</td>
</tr>
</tbody>
</table>
Structural integrity assessment

- **Technology:** *Magnetic Flux Leakage*
  - In-line, sized to match pipe
  - Scans through mortar coating
  - Requires full-diameter access
  - Characterizes PCCP strand damage, small pits in ferrous walls
  - Cracks are often not detected

In-line tool with the finest resolution available for PCCP testing
Structural integrity assessment

- **Live-pipe, free-swimming test of PCCP pipe walls**

- **Technology:** **Remote Field Transformer Coupling (Pipe Diver)**
  - In-line, scans through mortar coating
  - Launch in live force main
  - Characterizes PCCP strand damage, ferrous pipe wall damage
  - Navigates bends, valves
Structural integrity assessment

- Technology: **SONAR, P-wave electromagnetics, CCTV, laser profiling, (robotic platform)**
  - In-line, tethered
  - Crawl 40 feet/min., ≤8,000 feet
  - Float ≤16,000 feet
  - Characterizes PCCP strand damage, profiles, visual assessment

Flooded-pipe platform that can test PCCP pipe walls
## Structural integrity assessment

<table>
<thead>
<tr>
<th></th>
<th>Magnetic Flux Leakage Pig</th>
<th>Pipe Diver (free-swimming)</th>
<th>Robotic (tethered)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology</strong></td>
<td>Magnetic Flux Leakage</td>
<td>Remote Field Transformer Coupling</td>
<td>P-Wave EM, laser, CCTV, etc.</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>PCCP, BWP</td>
<td>PCCP, BWP</td>
<td>PCCP, BWP</td>
</tr>
<tr>
<td><strong>Sizes</strong></td>
<td>8“-78”</td>
<td>24“-96”</td>
<td>18“-72”</td>
</tr>
<tr>
<td><strong>Preparation</strong></td>
<td>Access: Full inter. diameter</td>
<td>Access: 12” ports</td>
<td>Access: 14”x16”</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$40,000/$40,000</td>
<td>$40,000/$40,000</td>
<td>$40,000/$40,000</td>
</tr>
</tbody>
</table>
Agenda: Condition Assessment

1. What we are doing
2. What we can do
3. Guidelines for implementation
Guidelines for implementation

- Watch out for big data.
- Pick the technology that fits your force main and budget.
- Start simple, invest more as you know more.
- Prioritize your efforts.
Questions?

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